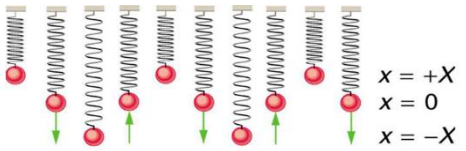
Physics 07-02 Hooke's Law and Simple Harmonic Motion Name: _____

Hooke's Law



$$F = -kx$$

- F = restoring _____, x = _____ displaced, k = spring _____
- Force will _____ the mass back toward _____
- As mass gets to _____, it has _____, so it continues past

Energy in Hooke's Law

- Since a force acts over a distance, _____ is done

$$PE_{el} = \frac{1}{2}kx^2$$

A Nerf dart gun uses a spring to launch a dart. If it takes 24 N of force to compress the spring 6 cm, what is the spring constant? How much potential energy does it contain?

Speed of a Wave on a String

- On a string, if one part of the string is pulled up (_____),
  - Then the next piece of the string is _____
  - Then the next piece of the string is _____, etc.
  - After the pulse passed the string moves back down to the _____ position due to _____
  - The more _____, the quicker the string _____ back and the _____ the wave travels.
- Speed of a wave depends on the _____
- For a string, the speed depends on
  - _____
  - Linear _____ (m/L)

$$v = \sqrt{\frac{F}{m/L}}$$

Simple harmonic motion

- Motion that regularly _____
- Frequency _____ of amplitude

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$$

- Think of a point on a string some _____ (x) from the _____
- We want to know the vertical _____ (y) of the particle at any given _____
- If the wave repeats, then it will look like a _____ (or _____) graph

$$y = A\cos\left(\frac{2\pi t}{T}\right)$$

A wave has an amplitude of 1.5 cm, a speed of 20 m/s, and a frequency of 100 Hz. Write the equation of the wave position of the wave.

Homework

1. A wire is strung tightly between two immovable posts. Discuss how an increase in temperature affects the speed of a transverse wave on this wire. Give your reasoning, ignoring any change in the mass per unit length of the wire.
2. A rope of mass *m* is hanging down from the ceiling. Nothing is attached to the loose end of the rope. A transverse wave is traveling on the rope. As the wave travels up the rope, does the speed of the wave increase, decrease, or remain the same? Give a reason for your choice.
3. Explain why you expect an object made of a stiff material to vibrate at a higher frequency than a similar object made of a spongy material.
4. As you pass a freight truck with a trailer on a highway, you notice that its trailer is bouncing up and down slowly. Is it more likely that the trailer is heavily loaded or nearly empty? Explain your answer.
5. Fish are hung on a spring scale to determine their mass (most fishermen feel no obligation to truthfully report the mass). (a) What is the force constant of the spring in such a scale if it the spring stretches 8.00 cm for a 10.0 kg load? (b) What is the mass of a fish that stretches the spring 5.50 cm? (c) How far apart are the half-kilogram marks on the scale? (OpenStax 16.1) **1.23×10^3 N/m, 6.88 kg, 4.00 mm**
6. It is weigh-in time for the local under-85-kg rugby team. The bathroom scale used to assess eligibility can be described by Hooke's law and is depressed 0.75 cm by its maximum load of 120 kg. (a) What is the spring's effective spring constant? (b) A player stands on the scales and depresses it by 0.48 cm. Is he eligible to play on this under-85 kg team? (OpenStax 16.2) **1.57×10^5 N/m, 77 kg, yes**
7. One type of BB gun uses a spring-driven plunger to blow the BB from its barrel. (a) Calculate the force constant of its plunger's spring if you must compress it 0.150 m to drive the 0.0500-kg plunger to a top speed of 20.0 m/s. (b) What force must be exerted to compress the spring? (OpenStax 16.3) **889 N/m, 133 N**
8. The mass of a string is 5.0×10^{-3} kg, and it is stretched so that the tension in it is 180 N. A transverse wave traveling on this string has a frequency of 260 Hz and a wavelength of 0.60 m. What is the length of the string? (Cutnell 16.12) **0.68 m**
9. The linear density of the A string on a violin is 7.8×10^{-4} kg/m. A wave on the string has a frequency of 440 Hz and a wavelength of 65 cm. What is the tension in the string? (Cutnell 16.13) **64 N**
10. A transverse wave is traveling with a speed of 300 m/s on a horizontal string. If the tension in the string is increased by a factor of four, what is the speed of the wave? (Cutnell 16.15) **600 m/s**
11. A type of cuckoo clock keeps time by having a mass bouncing on a spring, usually something cute like a cherub in a chair. What force constant is needed to produce a period of 0.500 s for a 0.0150-kg mass? (OpenStax 16.13) **2.37 N/m**
12. If the spring constant of a simple harmonic oscillator is doubled, by what factor will the mass of the system need to change in order for the frequency of the motion to remain the same? (OpenStax 16.14) **M = 2m**
13. A 0.500-kg mass suspended from a spring oscillates with a period of 1.50 s. How much mass must be added to the object to change the period to 2.00 s? (OpenStax 16.15) **0.389 kg**
14. A diver on a diving board is undergoing simple harmonic motion. Her mass is 55.0 kg and the period of her motion is 0.800 s. The next diver is a male whose period of simple harmonic oscillation is 1.05 s. What is his mass if the mass of the board is negligible? (OpenStax 16.18) **94.7 kg**
15. Suppose a diving board with no one on it bounces up and down in a simple harmonic motion with a frequency of 4.00 Hz. The board has an effective mass of 10.0 kg. What is the frequency of the simple harmonic motion of a 75.0-kg diver on the board? (OpenStax 16.19) **1.37 Hz**